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AUTHOR Pearson, Jane L.; Ialongo, Nicholas S.
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ABSTRACT

The ecological validity of three spatial ability tests was studied: The Embedded Figures Test, the Shepard/Metzler Mental Rotations Test, and the Differential Aptitude Spatial Relations subtest. The Building Memory Test was also examined in an attempt to replicate a previous study which supported its validity. These four tests were administered to 353 undergraduate students, along with two measures of environmental knowledge, a landmark location task and a route knowledge task. Both of these tasks were based on a slide-simulated walk through an unfamiliar urban environment. As hypothesized, the Differential Aptitude Test was predictive of both environmental tasks. Both the Building Memory Test and Embedded Figures Test were related to the landmark location task. However, overall, the spatial tests were more related to each other than to the two environmental tasks. Although mental rotation and disembedding appear to be part of the skills necessary to replicate a cognitive map, researchers would do well to distinguish spatial ability from environmental cognition. (Author/GDC)

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THE ECOLOGICAL RELEVANCE OF FOUR PSYCHOMETRIC MEASURES OF SPATIAL ABILITY

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Jane L. Pearson

Nicholas S. Ialongo

Department of Psychology
Michigan State University
East Lansing, MI 48824

Paper presented at the 92nd Annual Convention of the American Psychological Association, Toronto, Ontario.

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ABSTRACT

The present study sought to determine the ecological relevance of three psychometric measures of spatial ability--the Embedded Figures Test (EFT), the Shepard/ Metzler Mental Rotations Test (MRT), the Differential Aptitude Spatial Relations subtest (DAT)--and to replicate the findings of Walsh, Krauss & Regnier (1981) with a fourth psychometric measure of spatial ability--the ETS Building Memory Test (BMT). 353 college undergraduates were administered the EFT, MRT, DAT, BMT and two measures of environmental knowledge--a landmark location task (LM) and a route knowledge task (RK). The two environmental tasks were based on a slide simulated walk through an unfamiliar urban environment. As hypothesized, one of the mental rotation tasks--the DAT--was predictive of the environmental tasks, accounting for 5% of the variance in the RK task, and 9% of the variance in the LM task. Based on simple correlations, both the BMT and EFT were related to the LM task. However, overall the spatial ability tasks were more related to each other, than to the individual environmental tasks.

INTRODUCTION

There is growing recognition in the literature of the need for ecological validity in psychological research. An increasing number of researchers in the area of human learning and memory have begun to assess how relevant, or ecologically valid various experimental tasks are to adult life (e.g., Neisser, 1976; Walsh & Baldwin, 1977; Hartley, Harker & Walsh, 1980). However, with the exception of Walsh, Krauss & Regnier (1981), there have been no studies of the relevance of existing measures of spatial ability to environmental knowledge and use. In this one exception, Walsh et al. found that performance on two standardized measures of spatial ability--the Primary Mental Abilities Spatial Relations subtest and the ETS Building Memory Test--correlated highly with accuracy of locating neighborhood landmarks in a sample of elderly adults. While the Walsh et al. study is clearly a step in the direction of ecological validity, it must be considered only an initial one, in that spatial ability is a multidimensional construct, and that the PMA Spatial Relations (PMA) and Building Memory Test (BMT) may only be tapping some of the factors relevant to this construct.

Indeed, there may be a number of commonly used tests of spatial ability that tap factors relevant to environmental knowledge and use. The Embedded Figures, in the strictest interpretation, measures competence at perceptual disembedding. It seems plausible that determing the location of an object in an environment as a reference point, such as a landmark, would require similar disembedding skills; those individuals who are more field independent would perform better at determining landmarks. The Shephard/Metzler Mental Rotations Test (MRT) and the Differential Aptitude Spatial Relations subtest (DAT) tap the ability to rotate three-dimensional objects in space. Relatedly, Moore (1979) has hypothesized that mental rotation is a specific ability in cognitive mapping.

The present study sought to determine the ecological relevance of these three tests--the EFT, MRT and DAT--and to replicate the findings of Walsh et al. with the BMT. The dependent measures in the present study included a landmark location task, and a route knowledge task. Both were based on a slide-simulated walk through an unfamiliar urban environment, similar to the tasks described by Allen, Siegel and Rosinsksi (1978). In the route knowledge task (RK), subjects drew on a city-block map the route they believed they had just "traveled", given starting and end points (see Figure 1). In the landmark location task (LM), the subjects were shown 16 slides of various scenes along the route, and were asked to locate them on their route maps (RK) (see Figure 2).

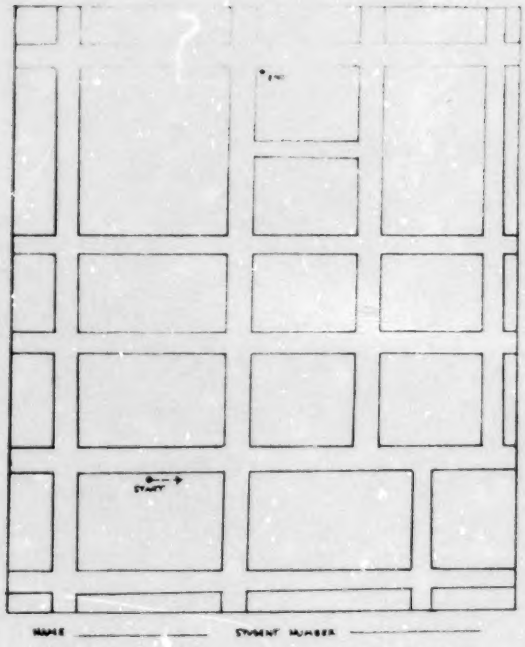

Figure 1. City-block map used for Route Knowledge Task.

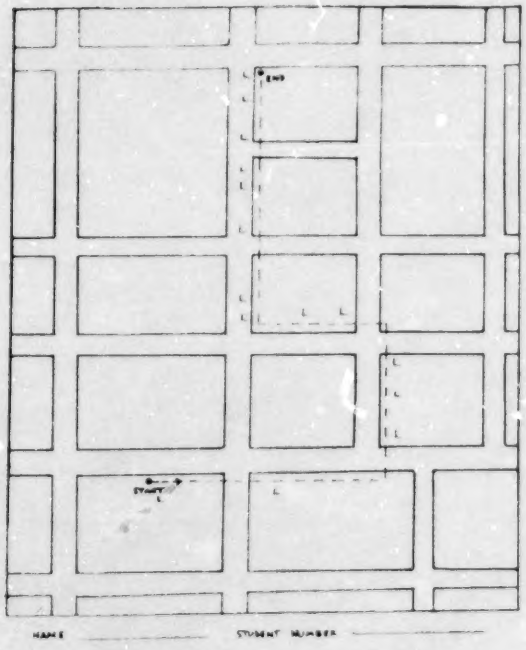

Figure 2. Map and route indicating correct location of landmarks.

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METHOD

Subjects. The subjects were 199 women and 154 men from the introductory psychology classes at Michigan State University.

Instruments. The four spatial ability measures used were: 1) The Group Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971); 2) Vandenberg's adapation of the Shephard/ /Metzler Mental Rotation Test (Vandenberg & Kuse, 1978); 3) The Differential Aptitude Spatial Relations subtest (Bennett, Seashore & Wesman, 1974); and 4) a revised version of the ETS Building Memory Test (Krauss, Awad & McCormick, 1981). For a complete description of the environmental knowledge tasks used (RK, LM), see Pearson (1982).

Procedure. Testing was conducted in a classroom equipped with a projection screen and writing surfaces for up to 30 people. The experimenters administered the tests to 19 groups with an average of 20 people in each group. The testing lasted for two hours, with a ten minute break half-way through the testing session. Procedures and materials for the EFT, MRT, BMT (with a reduced time adjustment) and DAT were as described in the respective test manuals. In order to control for order effects, a Latin Square design was employed to determine test order for each testing session.

RESULTS & DISCUSSION

The correlational analysis among all measures revealed that the MRT and DAT were modestly related to both the LM and RK tasks ($p < .001$ for all four pairs, see Table 1). These findings support Moore's (1979) hypothesis that rotation plays some role in environmental knowledge. Despite the relatively high correlation between the LM and RK tasks ($r = .53$, $p < .001$), the EFT and BMT only correlated with the LM task. These results support Krauss et al. findings in part, and the relation between the EFT and LM suggest that disembedding may also play a part in environmental knowledge.

TABLE 1

CORRELATIONS AMONG PSYCHOMETRIC MEASURES

AND ENVIRONMENTAL TASKS

BMT	.35***				
MRT	.41***	.33***			
DAT	.55***	.48***	.59***		
RK	.09*	.08	.19***	.23***	
LM	.16***	.17***	.23***	.30***	.53***
	EFT	BMT	MRT	DAT	RK

*** $p < .001$

* $p < .05$

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To further test the relations between the spatial ability tests and the environmental knowledge tasks, hierarchial multiple regressions were conducted. Based on the correlation matrix, the following order of spatial ability tests were regressed on each of the environmental tasks (see Table 2): 1) DAT, 2) MRT, 3) BMT, and 4) EFT. For both the environmental tasks, only the DAT accounted for a significant part of the total variance. It appears that the variance not shared between the DAT and the other spatial ability tests does not contribute the to variance in the environmental knowledge tasks.

TABLE 2

HIERARCHICAL MULTIPLE REGRESSIONS TO

ROUTE KNOWLEDGE AND LANDMARK LOCATION

Route Knowledge

Variable	Multiple R	Cummulative R^2	Beta	F
1. DAT	.22	.05	.20	16.06***
2. MRT	.23	.05	.11	2.32
3. BMT	.23	.05	-.02	.32
4. EFT	.24	.06	-.05	.77

Landmark Location

Variable	Multiple R	Cummulative R^2	Beta	F
1. DAT	.29	.09	.23	30.84***
2. MRT	.31	.09	.10	2.32
3. BMT	.31	.09	.03	.15
4. EFT	.31	.09	-.03	.31

* $p < .05$

*** $p < .001$

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In summary, the ecological relevance of these spatial ability tests are limited. Although mental rotation and disembedding appear be a part of some of the skills necessary to replicate a cognitive map, researchers would do well to distinguish "spatial ability" from environmental cognition.

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